



# MICROWAVE INTEGRATED RETRIEVAL SYSTEM (MIRS): Scientific Activities, Project Milestones, Future Plans

**Chris Grassotti**

CICS-MD and NOAA/NESDIS/STAR

MiRS Team: S. Liu, R. Honeyager, Y-K. Lee, Q. Liu

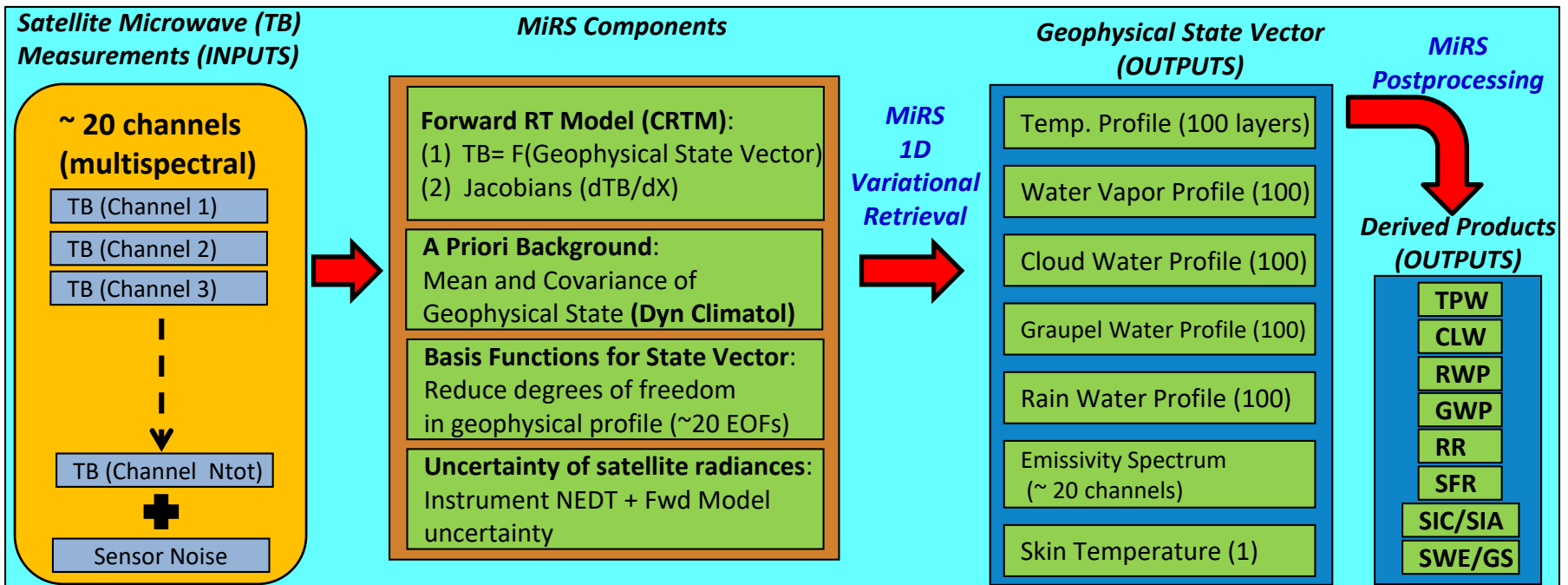
Help from: G. Chirokova, B. Sun, J. Forsythe

[christopher.grassotti@noaa.gov](mailto:christopher.grassotti@noaa.gov)

28 August 2018

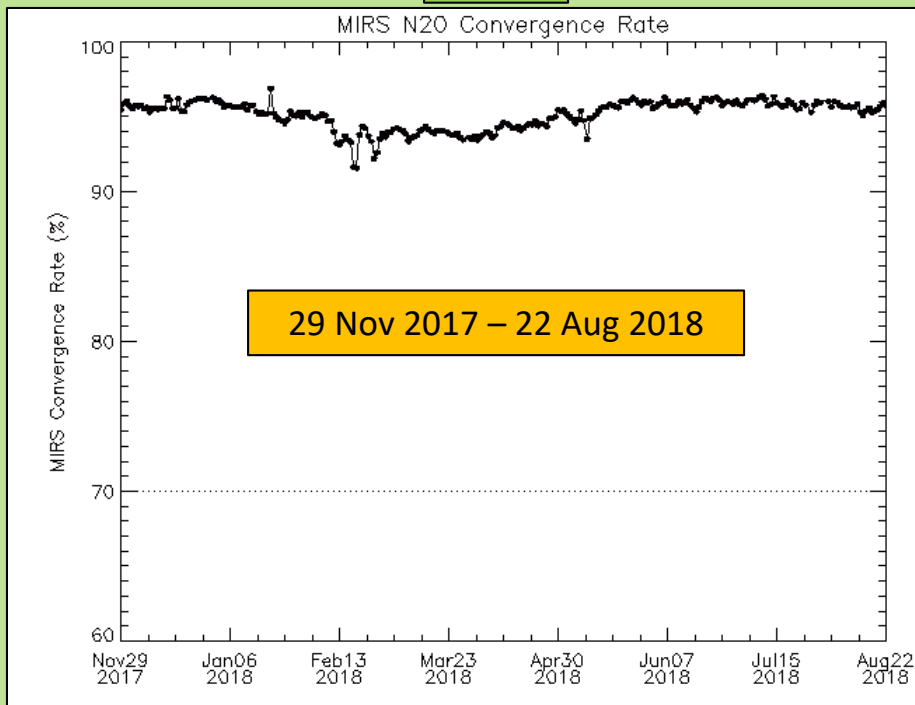
- **Beta Maturity** since 29 Nov 2017 (L+11 days)
- **Provisional Maturity** declared on 29 March 2018
- **V11.3 Preliminary DAP delivered to NDE/OSPO on 8 June**
- Possibly operational in September
- Additional validation ongoing, e.g. RR, cryosphere, T and WV vs. raobs, LST, and LSE, etc.
- An updated DAP will be delivered in late 2018/early 2019
- Also delivered to CSPP/DB in July (CSPP\_MIRS 2.1)

- Extension to NOAA-20/ATMS
- Addition of snowfall rate (SFR) to SNPP and N20 (not fully validated); SFR already implemented for AMSU-MHS
- Implementation of forest fraction emissivity correction in SWE algorithm for ATMS and AMSU-MHS (improved estimation in forested regions, e.g. eastern CONUS)
- Incorporation of cloud liquid water over land in RR algorithm for all satellites (improved detection/estimation of light rain)
- Miscellaneous fixes, changes to nc metadata, modifications to output nc file names

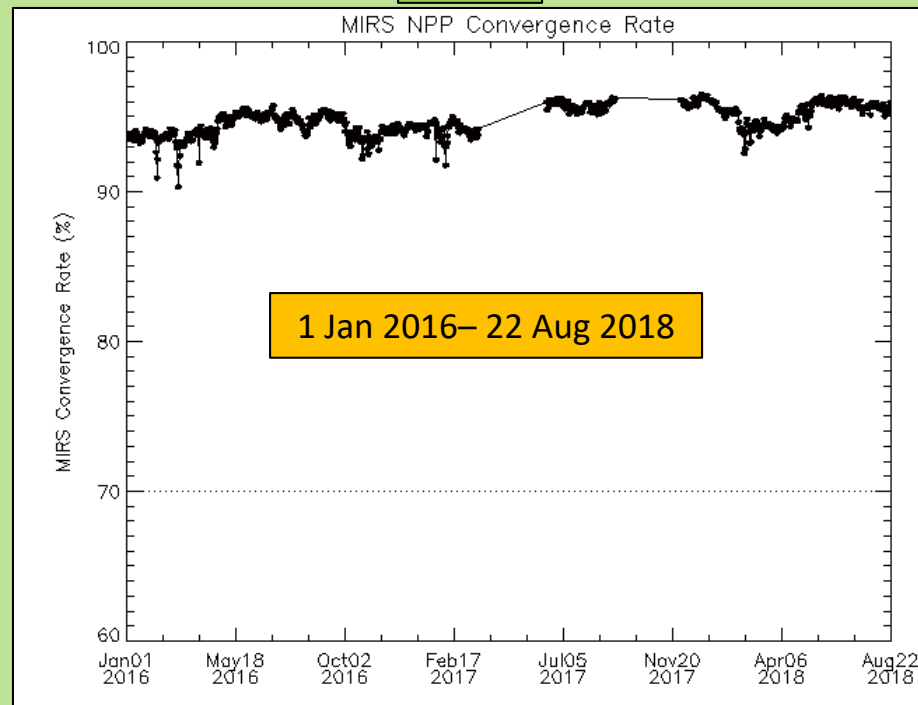


- MW Only, Variational Approach: Find the “most likely” atm/sfc state that: (1) best matches the satellite measurements, and (2) is still close to an a priori estimate of the atm/sfc conditions.
- **“Enterprise” Algorithm: Same core software runs on all satellites/sensors; facilitates science improvements and extension to new sensors.**
- Initial capability delivered in 2007. Running v11.2 since Jan 2017 on SNPP/ATMS, N18, N19, MetopA, MetopB, F17, F18, GPM/GMI, Megha-Tropiques/SAPHIR. (eventually MetopC...)
- Delivery of v11.3 (extended to NOAA-20/ATMS) to operations on **8 June**.
- External Users/Applications: TC Analysis/Forecasting at NHC, Blended Total/Layer PW Animations at NHC and WPC Animations (CSU/CIRA, U. Wisconsin/CIMSS), CSPP Direct Broadcast (U. Wisconsin), NFLUX model (NRL, Stennis), Global blended precipitation analysis at NOAA/CPC (CMORPH),...
- **All N20 results here are generated with MiRS v11.3 (offline processing in STAR), and TDR data generated in IDPS (Block 2 processing).**

N20

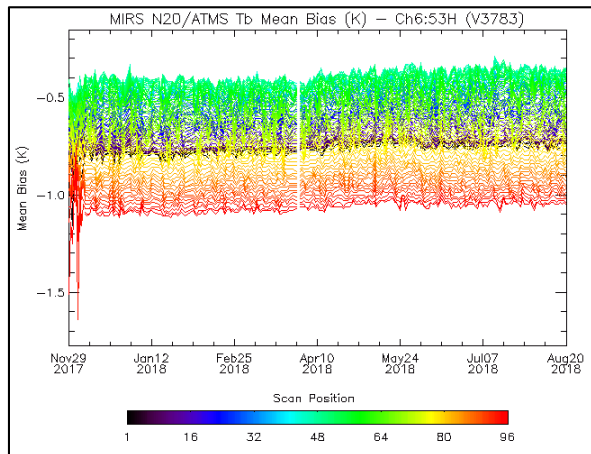


SNPP

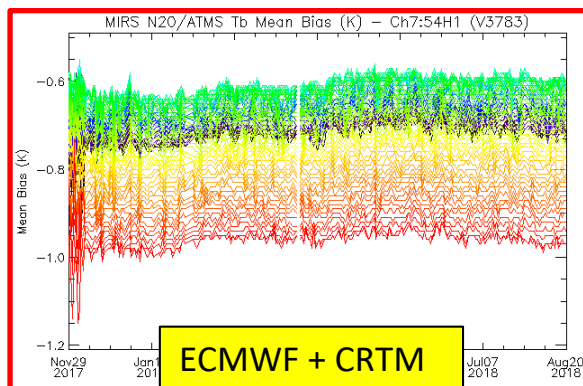


# Radiometric Biases: Time Series TDR Obs-Sim (29 Nov – 20 Aug)

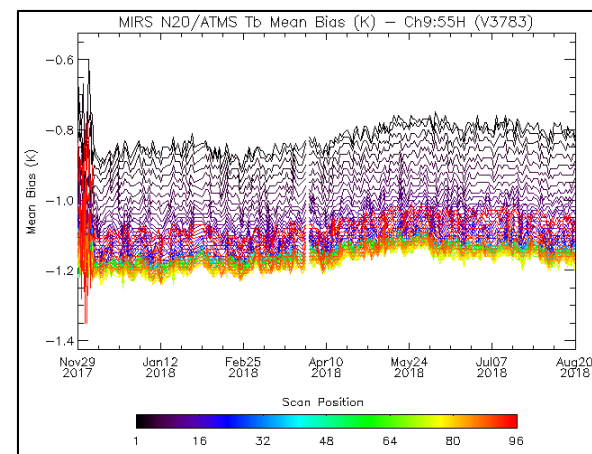
**Chan 6 ( $53.6 \pm 0.12$  GHz)**



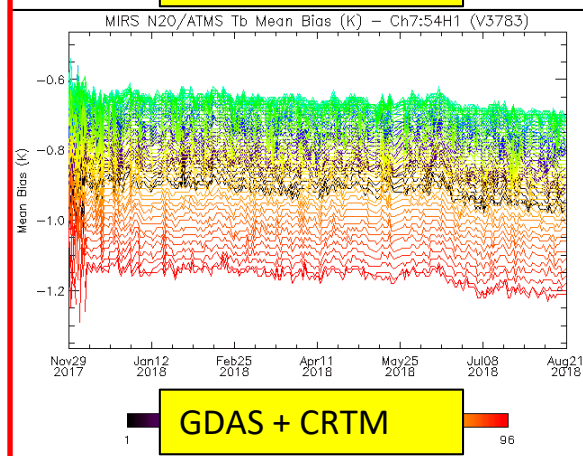
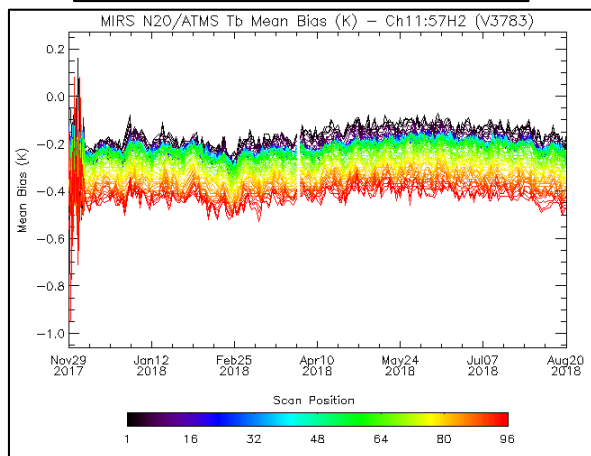
**Chan 7 (54.4 GHz)**



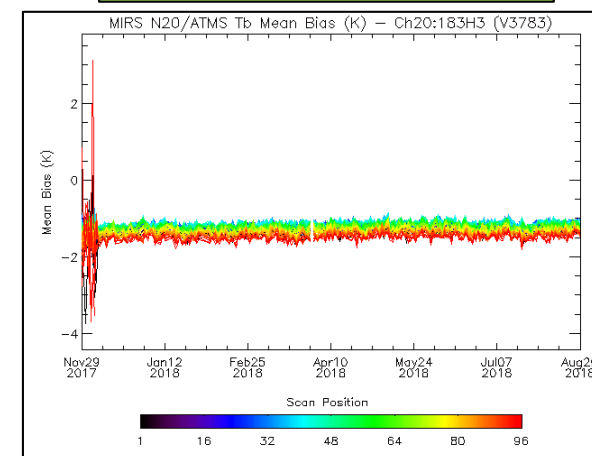
**Chan 9 (55.5 GHz)**



**Chan 11 ( $57.29 \pm 0.22$  GHz)**



**Chan 20 ( $183.31 \pm 3$  GHz)**



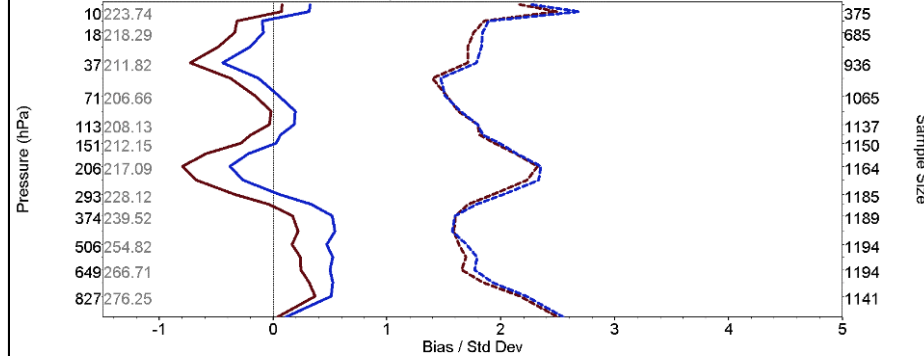
- Simulated TBs: ECMWF + CRTM (v2.1.1), clear ocean

# Temperature and WV Bias and Std Dev: Global (Land+Ocean) Comparison with Raobs

Courtesy of Bomin Sun

8-18 Jan 2018

Temperature (sat - baseline) deg K  
January 8, 2018 to January 18, 2018

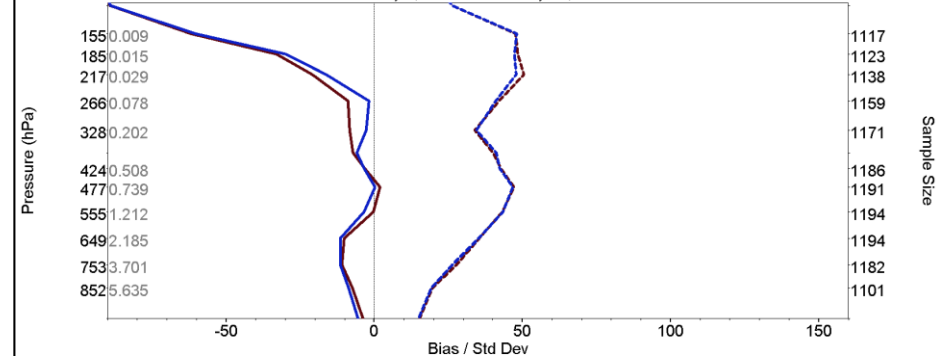


Baseline: SONDE

MIRS NPP v11

MIRS NOAA-20 Test

Water Vapor (sat - baseline) % error  
January 8, 2018 to January 18, 2018



TPW -40 -30 -20 -10 0 10 20 30 40 4284

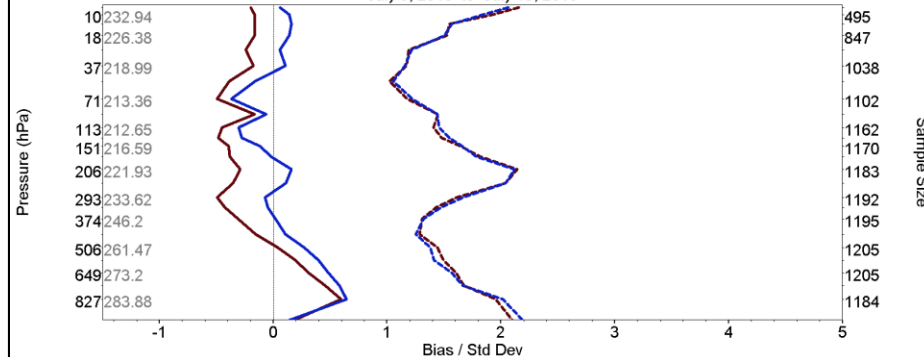
Baseline: SONDE

MIRS NPP v11

MIRS NOAA-20 Test

9-19 Jul 2018

Temperature (sat - baseline) deg K  
July 9, 2018 to July 19, 2018

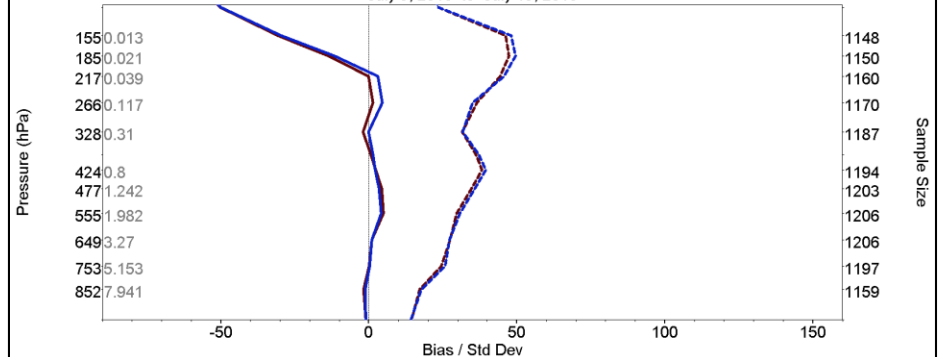


Baseline: SONDE

MIRS NPP v11

MIRS NOAA-20 Test

Water Vapor (sat - baseline) % error  
July 9, 2018 to July 19, 2018



TPW -40 -30 -20 -10 0 10 20 30 40 4508

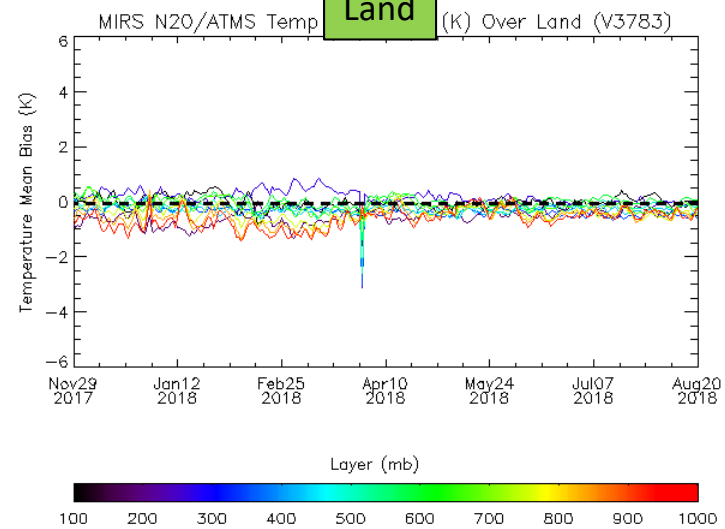
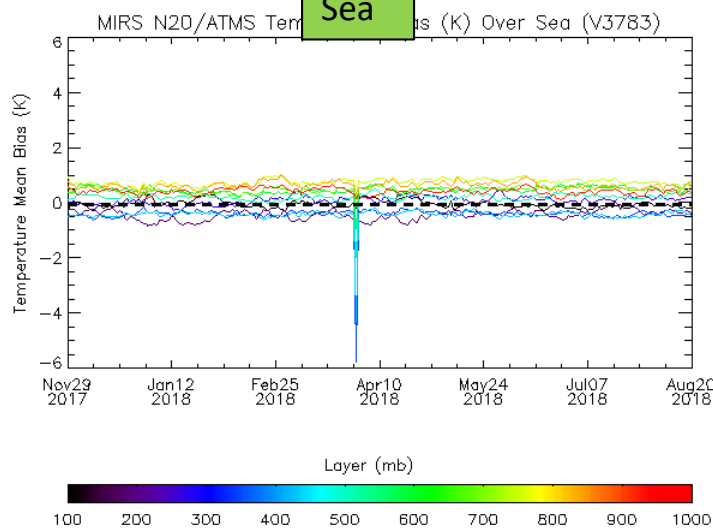
Baseline: SONDE

MIRS NPP v11

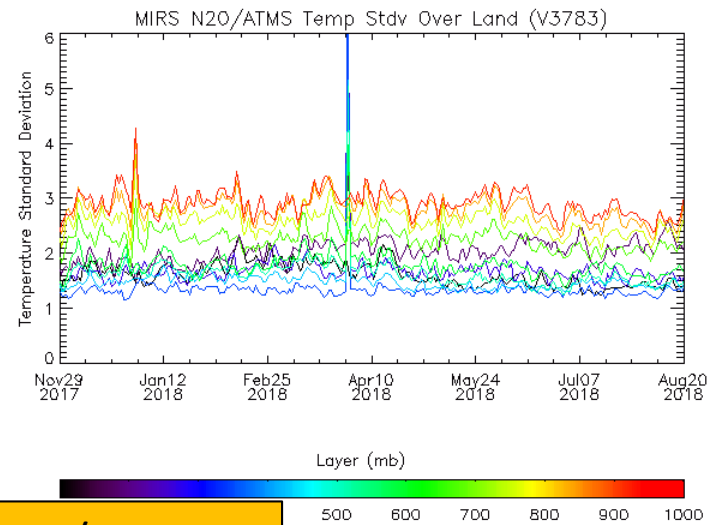
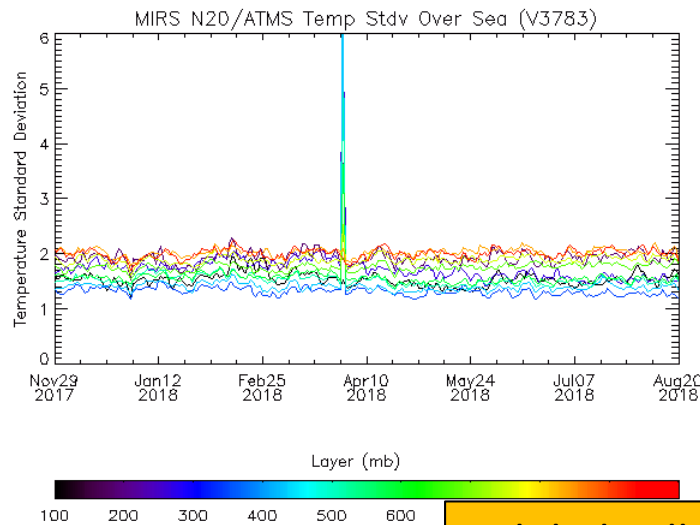
MIRS NOAA-20 Test

# Temperature Bias and Std Dev: Time Series (29 Nov – 20 Aug)

Bias



Stdv

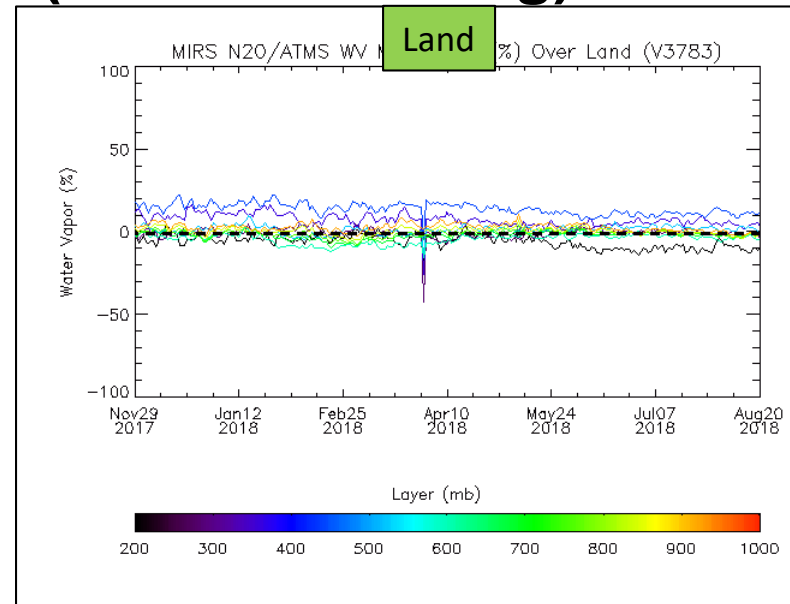
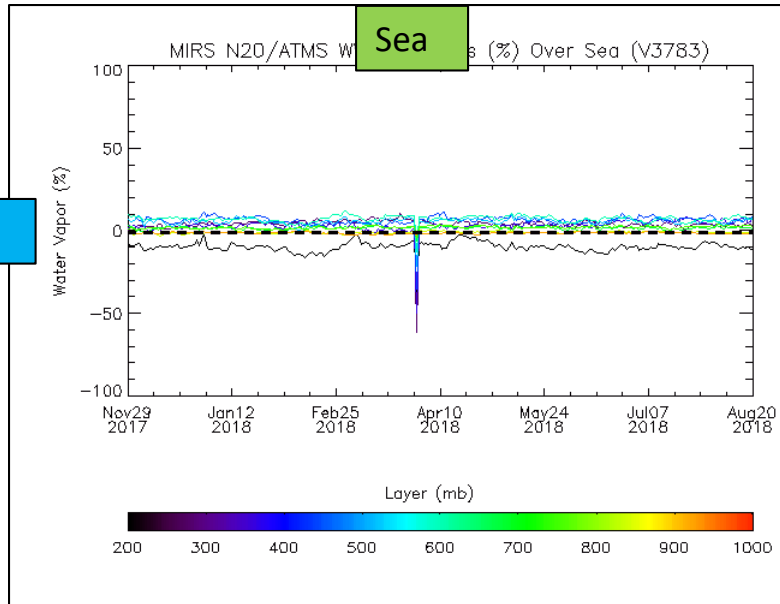


Global collocation w/ECMWF

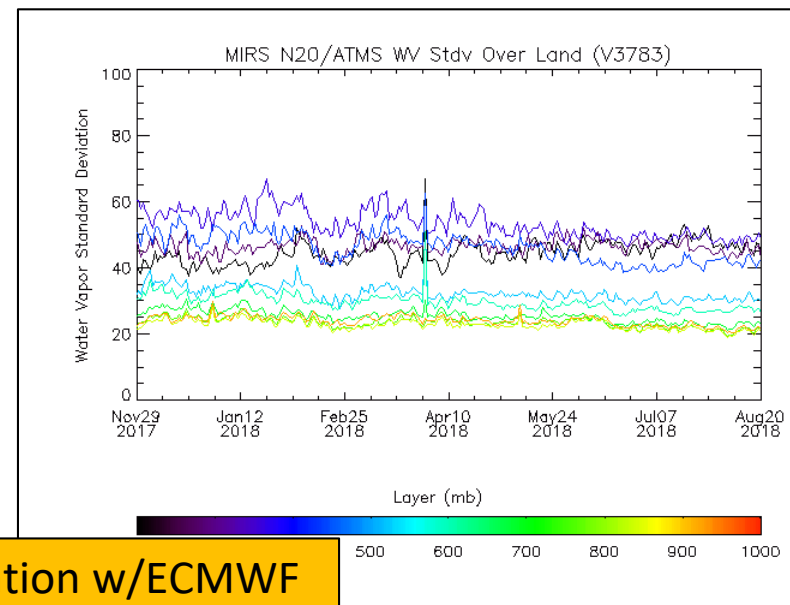
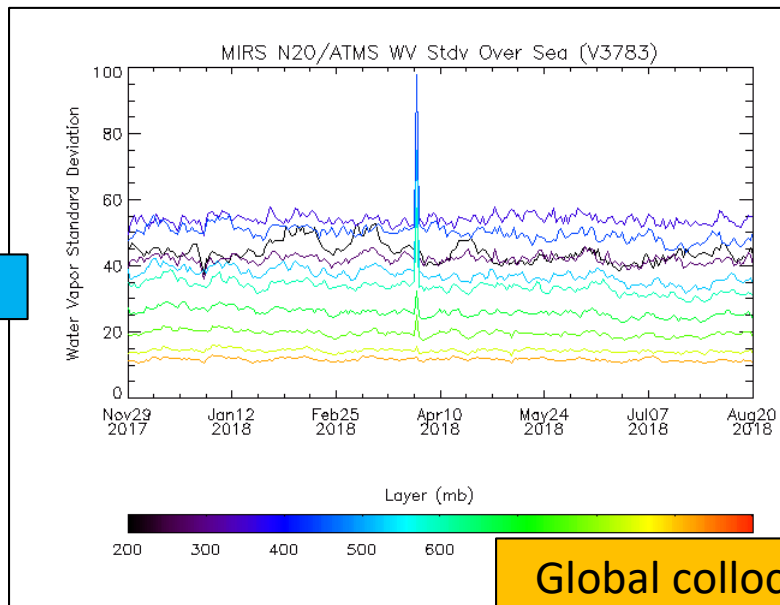


# Water Vapor Bias and Std Dev: Time Series (29 Nov – 20 Aug)

Bias



Stdv



Global collocation w/ECMWF

# Application Using MiRS Data: Hurricane Intensity and Structure Algorithm (HISA)

HISA provides MW-based TC Intensity estimates:

- Global
- Objective
- Independent of Dvorak

Input:

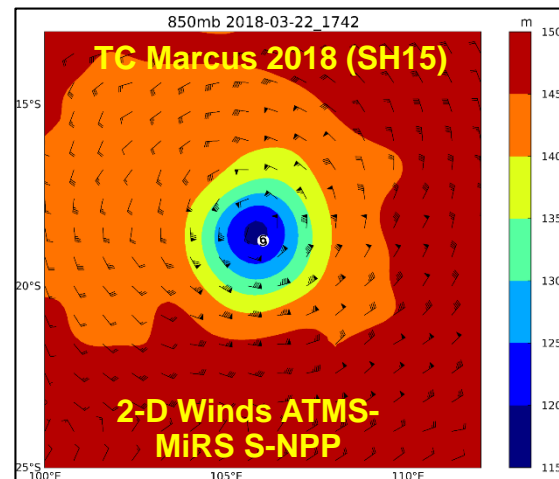
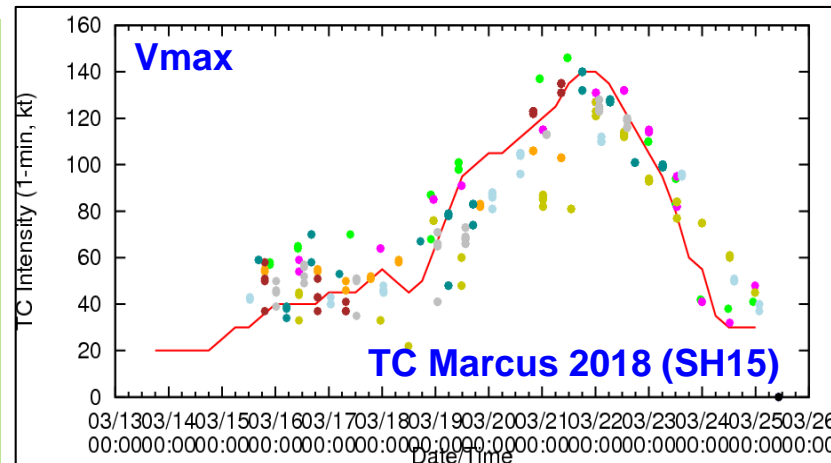
- Temperature profile, CLW from **AMSU/ATMS-MiRS** or statistical retrievals
- GFS boundary conditions
- ATCF TC track data

Output:

- 1) Intensity estimates, provided via f-deck
  - Maximum sustained wind (Vmax, kt)
  - Minimum Sea Level Pressure (MSLP, hPa)
- 2) Surface Wind Radii Estimates (nmi), provided via f-deck
  - R34, R50, R64 for NE, NW, SE, and SW TC quadrants
- 3) Azimuthally-averaged gradient winds as a function of geopotential height and distance from TC center.
- 4) Horizontal 2-D balanced winds (kt) for the local TC environment

Operational on ATMS and AMSU on 7 satellites, is upgraded to work with NOAA20 ATMS

Users: NHC, CPHC, JTWC



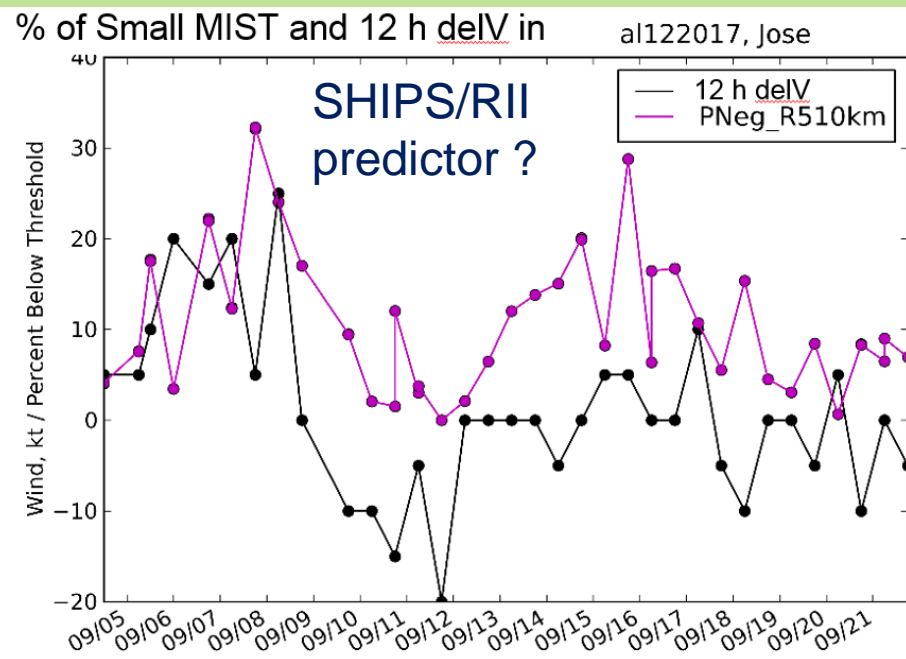
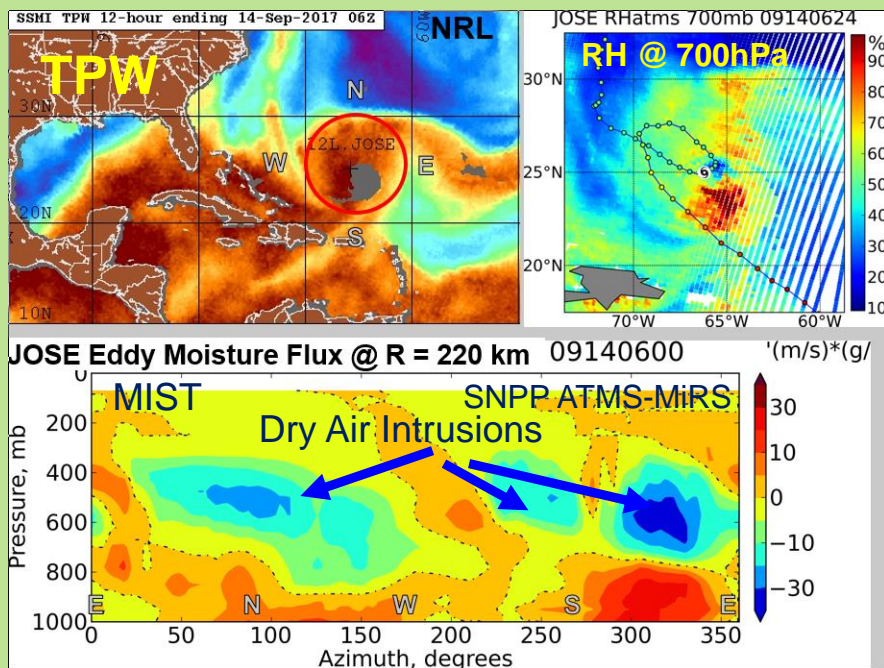
	ATMS-MIRS MAE	AMSU-MIRS MAE
Vmax (kts)	11.1 (1565)	13.2 (4346)
Pmin (hPa)	7.0 (1565)	8.4 (4347)
R34 (nmi)	20.0 (344)	24.9 (1044)
R50 (nmi)	12.0 (215)	10.6 (601)
R64 (nmi)	12.0 (134)	8.9 (336)

### Dry-air intrusions:

- adversely affect TCs: inhibit convection, enhance cold downdrafts, contribute to storm asymmetry
- detected with TPW, LPW, WV imagery which do not provide quantitative information and do not always reflect moisture changes at mid-levels

### MIST:

- detects and quantifies dry-air intrusions
- potential predictor for statistical TC intensity forecast models (SHIPS, LGEM, RII)



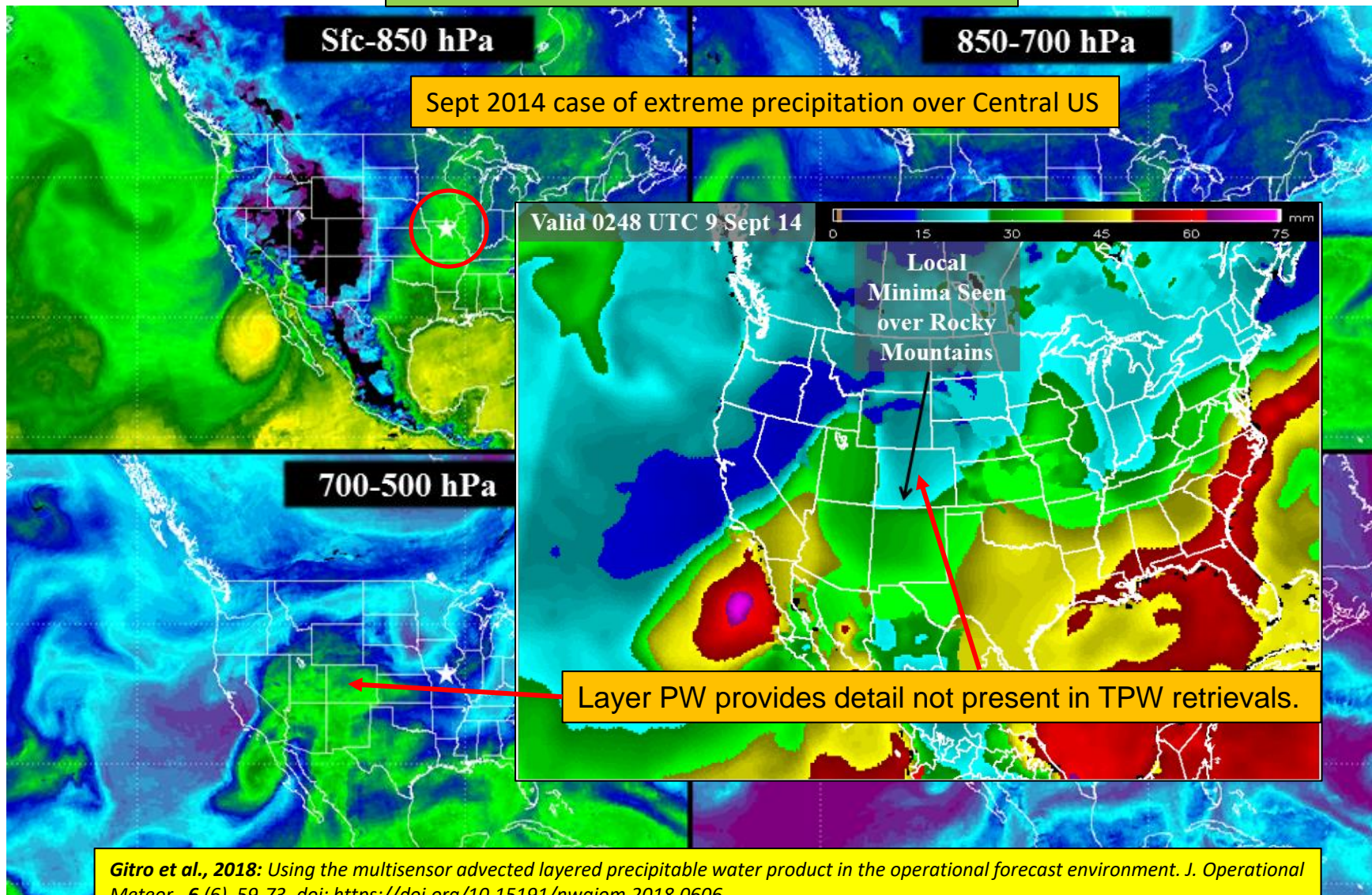
MIST shows moisture flux at R = 220 km from the storm center as a function of azimuth



# Application: Blended Layer Precipitable Water Combines MiRS WV from up to 7 Polar Satellites for Rapid Refresh and Advection (NWP-based winds)

To be implemented at NHC and WPC

Courtesy of John Forsythe



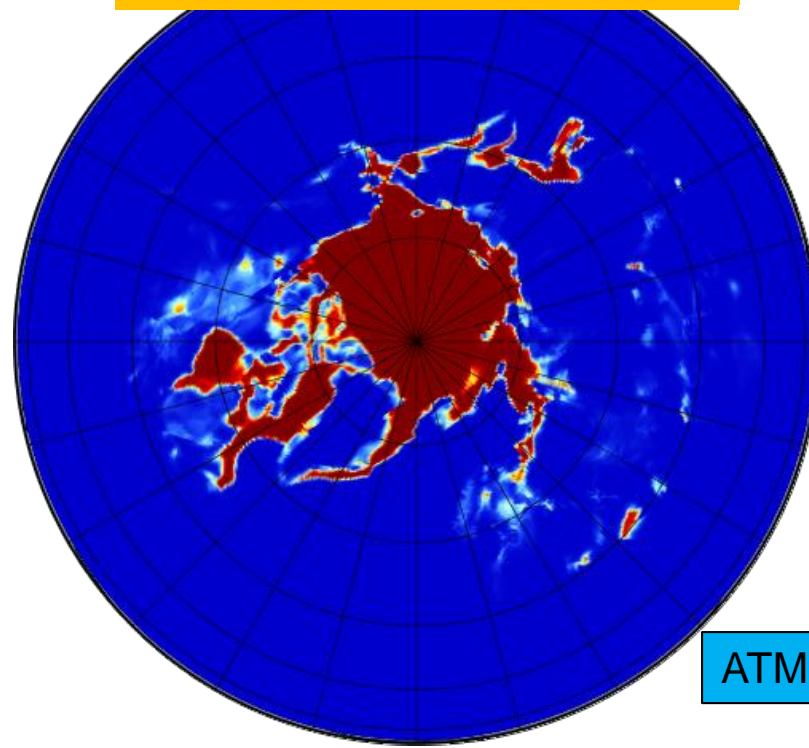
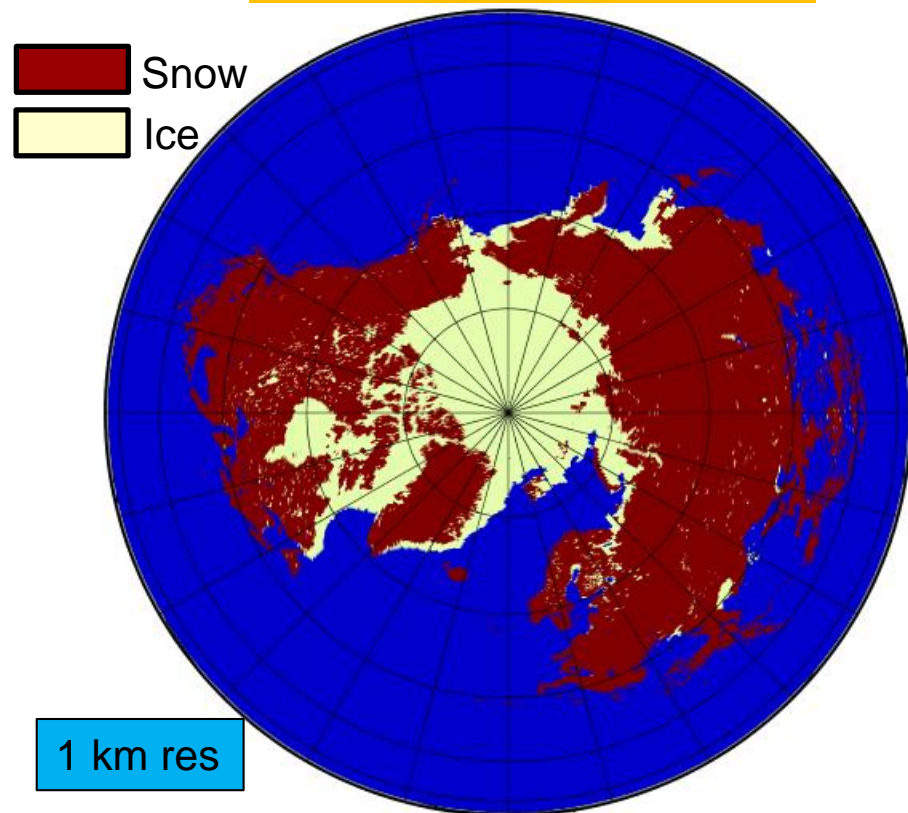
*Gitro et al., 2018: Using the multisensor advected layered precipitable water product in the operational forecast environment. J. Operational Meteor., 6 (6), 59-73, doi: <https://doi.org/10.15191/nwajom.2018.0606>*

# Future Development: Surface Classifier Using Machine Learning

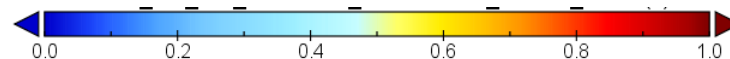
- Current MiRS surface type classifier is categorical (no mixed types): ocean, land, snow, ice
- Using TensorFlow to train a neural network to probabilistically classify surface types with IMS operational analyses as truth data
- Probabilistic surface type can be used to condition the a priori conditions for mixed surface types (e.g. emissivity) with potential impact on retrievals (e.g. ice concentration, snow water, T, WV profiles)

IMS (Observed)

Neural Net (Predicted)  
Probability of Ice



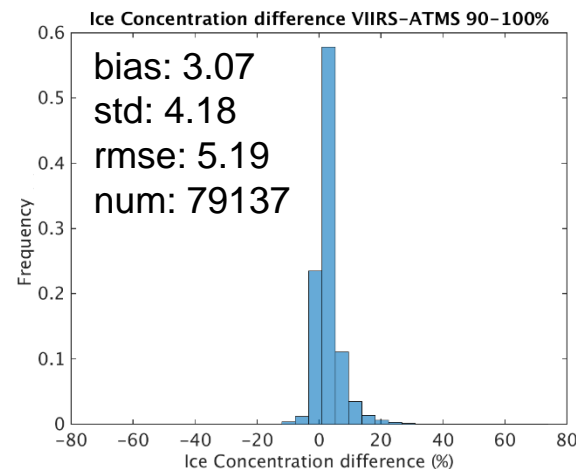
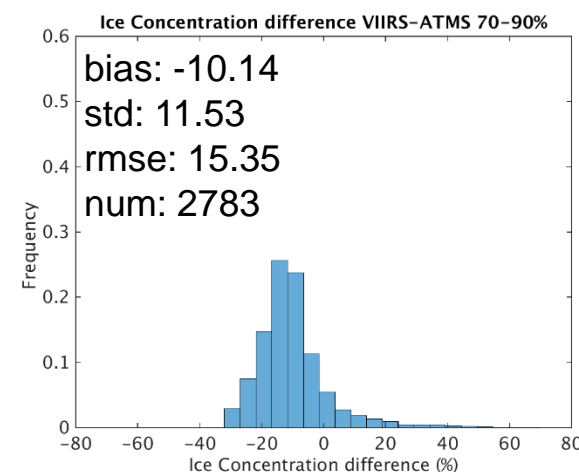
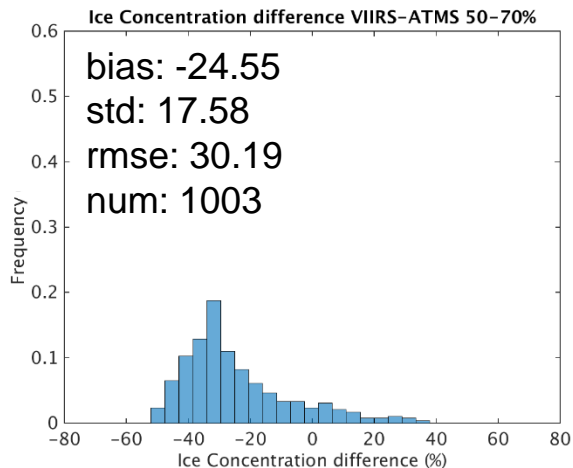
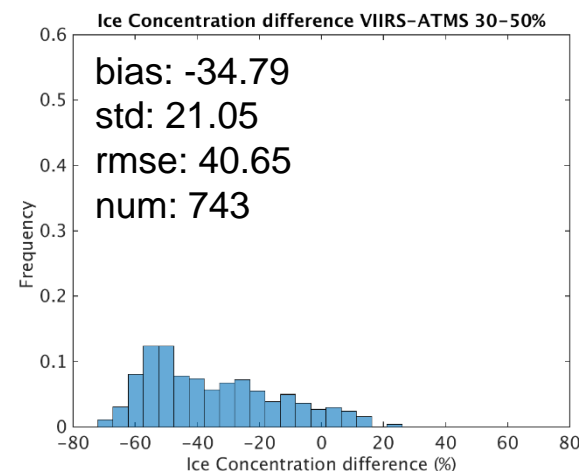
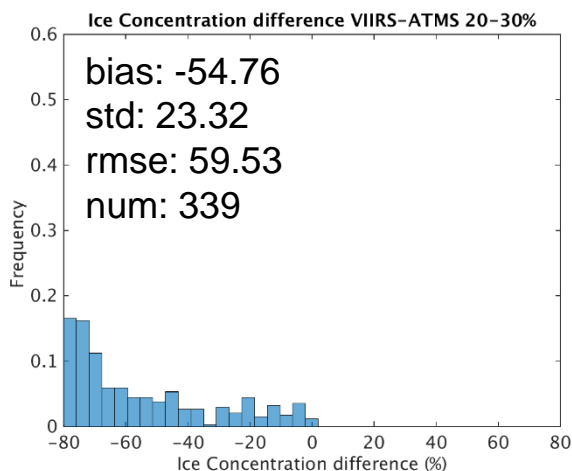
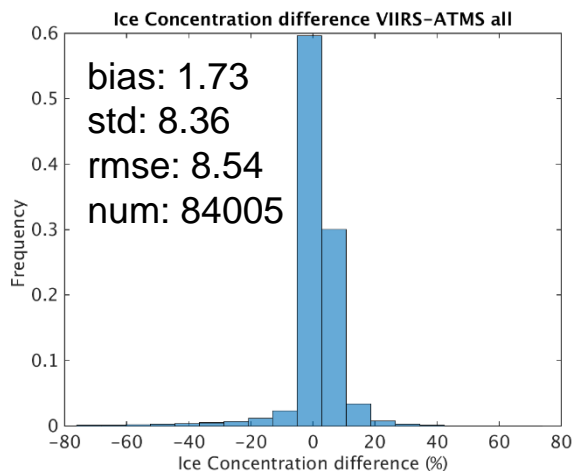
9 Jan 2016





# SNPP/ATMS Sea Ice Concentration and Age: Comparisons with VIIRS

- Collocations of VIIRS pixels that fall within each ATMS FOV
- Example from one day of global data: 29 Jan 2018

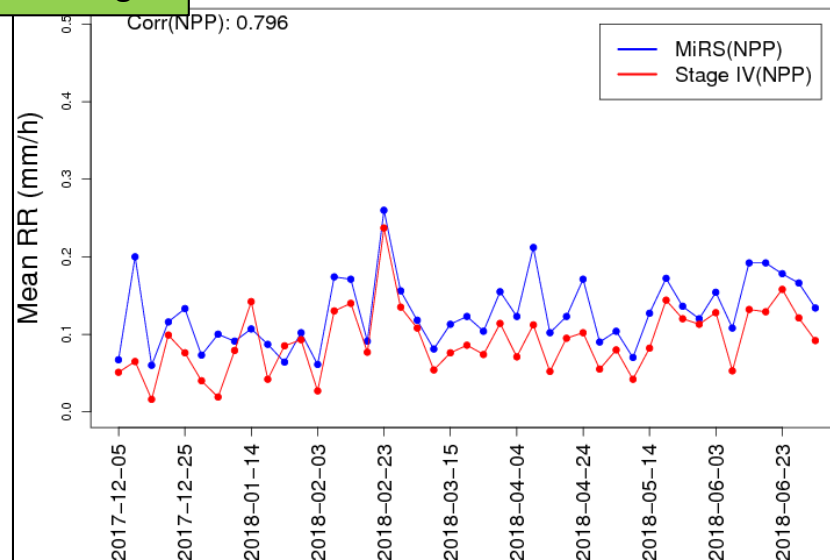
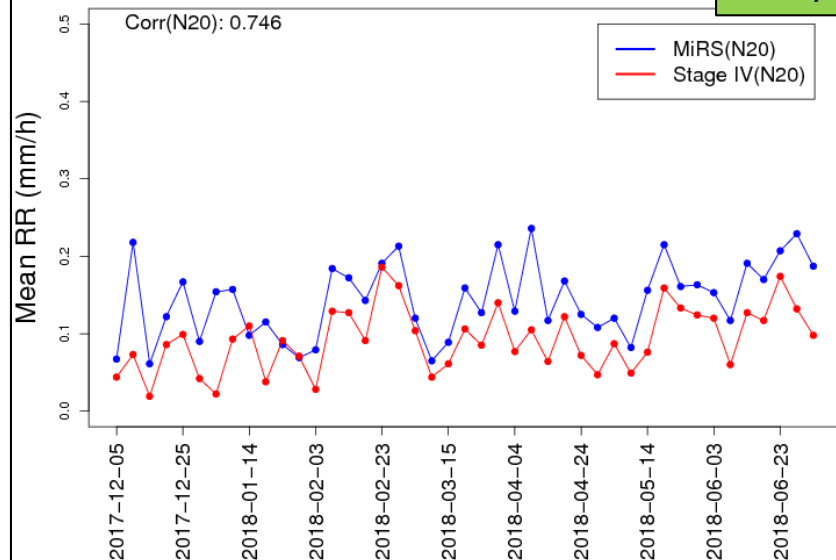


# RR validation: N20 and SNPP vs. Stage IV (Dec 2017 – Jul 2018)

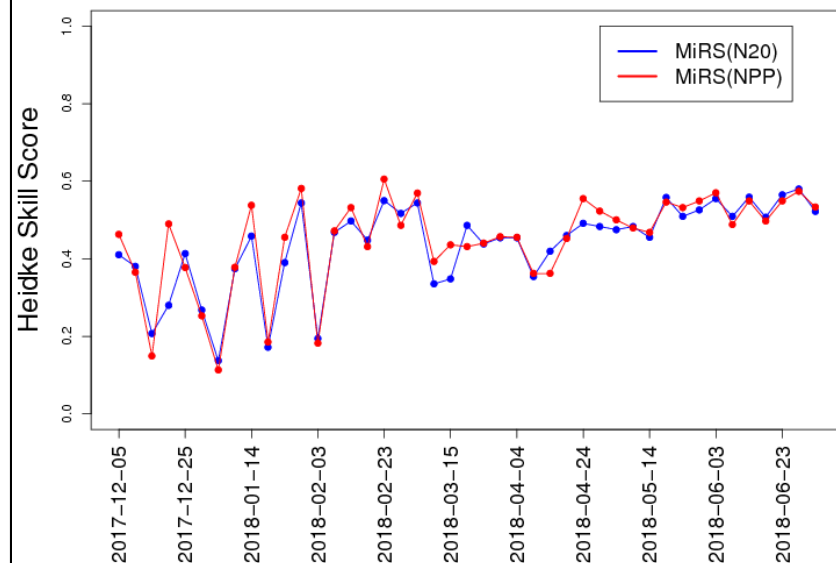
N20 Stage IV Collocation (Land)

5-Day CONUS Averages

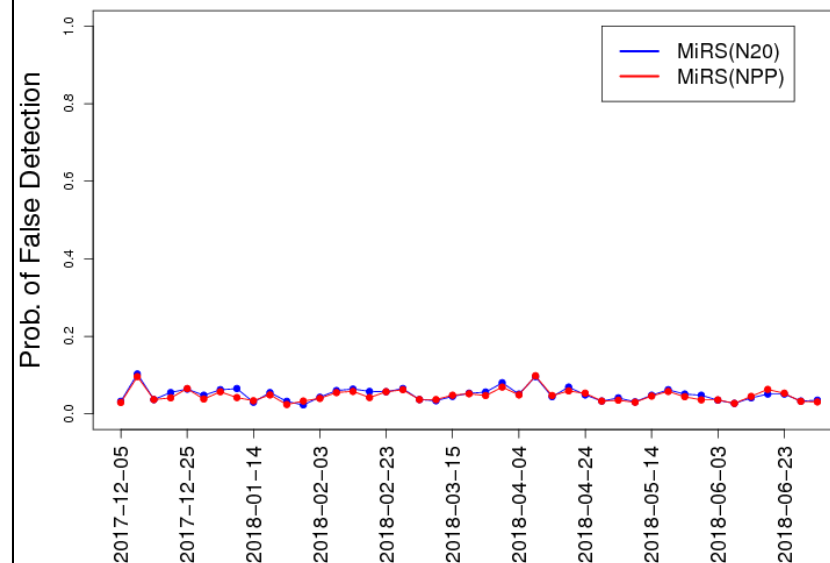
NPP Stage IV Collocation (Land)



N20/NPP Stage IV Collocation (Land)

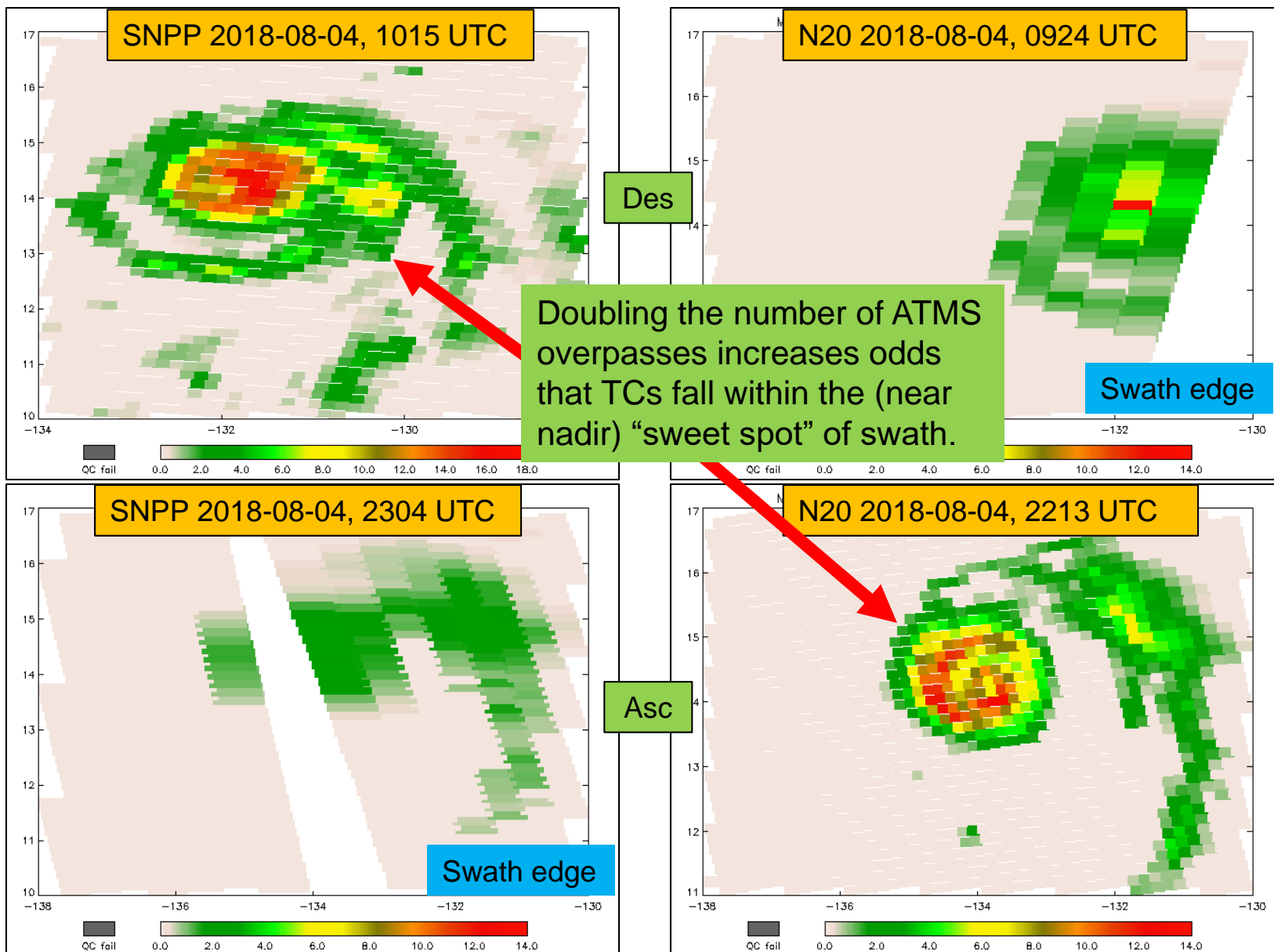


N20/NPP Stage IV Collocation (Land)



# Two Operational ATMS Better Than One: MiRS

## Rain Rate for Hurricane Hector





- Continued N20 validation indicates **extremely good agreement** with SNPP, and performance against external references very similar to SNPP; additional validation necessary
- Validation maturity status: Provisional maturity
- MiRS v11.3: Extension to N20 ATMS processing, delivered to OSPO/NDE on 8 June
- Path Forward
  - Continued validation, e.g. rain rate, CLW, cryosphere, T, WV,...
  - Additional DAP delivery in late 2018 (updated radiometric bias corrections, possible science improvements)
  - Extend to MetopC in 2019, JPSS-2, etc.
  - Science improvements (e.g. surface classification, bias correction, rainy sounding)
  - Longer term: EON-MW (SmallSats), Metop-SG (sounding, surface, and ice cloud missions)
  - Stakeholders/user needs; continue collaboration with applications developers and users...
- MiRS data available at CLASS, and STAR ftp (S-NPP/ATMS, NOAA-20/ATMS, GPM/GMI)
- Software package available for download **<https://www.star.nesdis.noaa.gov/mirs>**

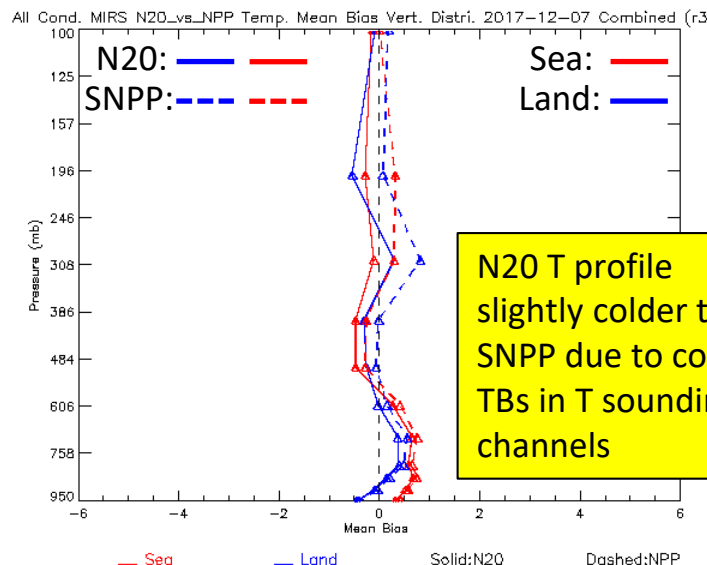


## Global collocation w/ECMWF

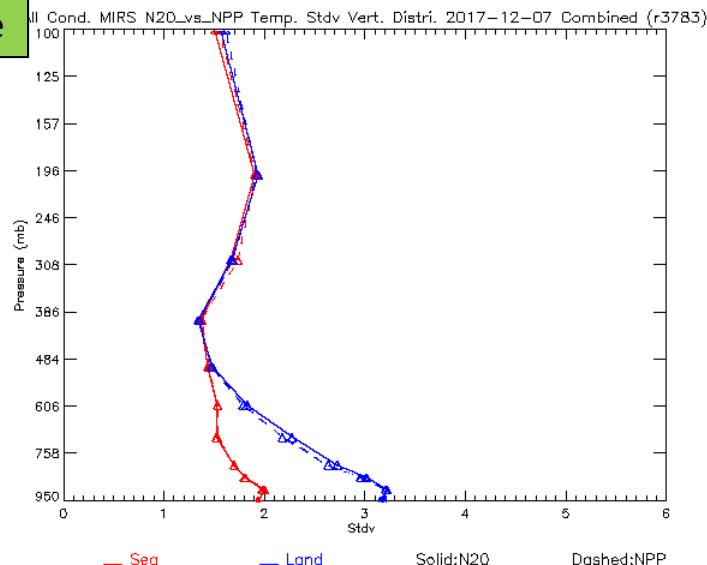
Bias

Stdv

Temperature



N20 T profile  
slightly colder than  
SNPP due to colder  
TBs in T sounding  
channels



Water Vapor

